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Shiraishi et al.

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(54) **PAPER FEEDING DEVICE AND IMAGE FORMING DEVICE**

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B65H 5/22 (2006.01)
(Continued)

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CPC ***B65H 3/14*** (2013.01); ***B65H 3/128*** (2013.01); ***B65H 3/48*** (2013.01); ***B65H 5/222*** (2013.01); *B65H 2406/364* (2013.01); *B65H 2406/42* (2013.01)

(58) **Field of Classification Search**
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USPC 271/11, 90, 104, 105, 106, 96–98
See application file for complete search history.

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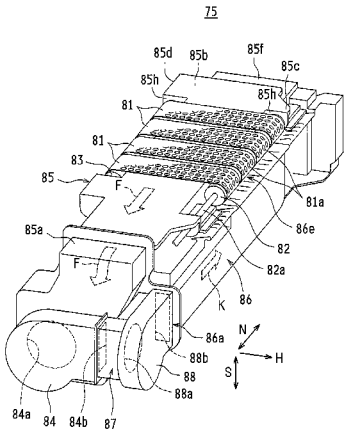
Primary Examiner — Patrick Cicchino
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye, P.C.

(57) **ABSTRACT**

Disclosed is a paper feeding device (**71**) including: a paper stacking tray (**74**) that carries thereon stacked sheets of printing paper and moves up/down along a stacking direction of the sheets of printing paper; a paper transport member (e.g., paper transport belts (**81**)) that sucks and transports a sheet of printing paper from the paper stacking tray (**74**); a separation fan (**88**) that generates an air flow separating the printing paper stacked on the paper stacking tray (**74**); an air sucking fan (**84**) that generates an air flow sucking a sheet of printing paper stacked on the paper stacking tray (**74**); and a relay duct (**87**) that guides air coming out of the air sucking fan (**84**) to the separation fan (**88**). The relay duct (**87**) extends along a straight line from an air outlet (**84***b*) of the air sucking fan (**84**) to an air inlet (**88***a*) of the separation fan (**88**).

20 Claims, 13 Drawing Sheets



(51) **Int. Cl.**
B65H 3/48 (2006.01)
B65H 3/12 (2006.01)

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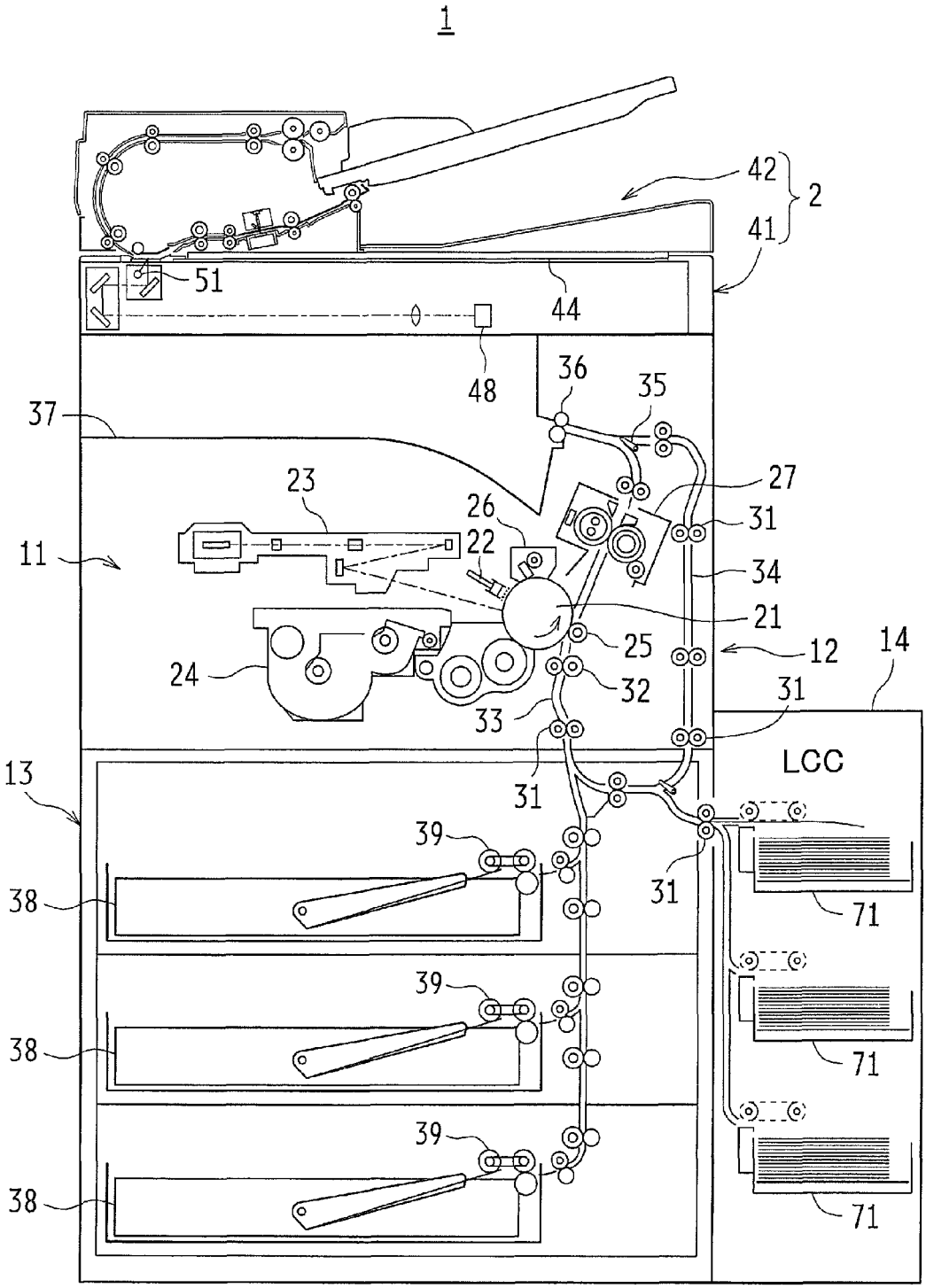
FIG.1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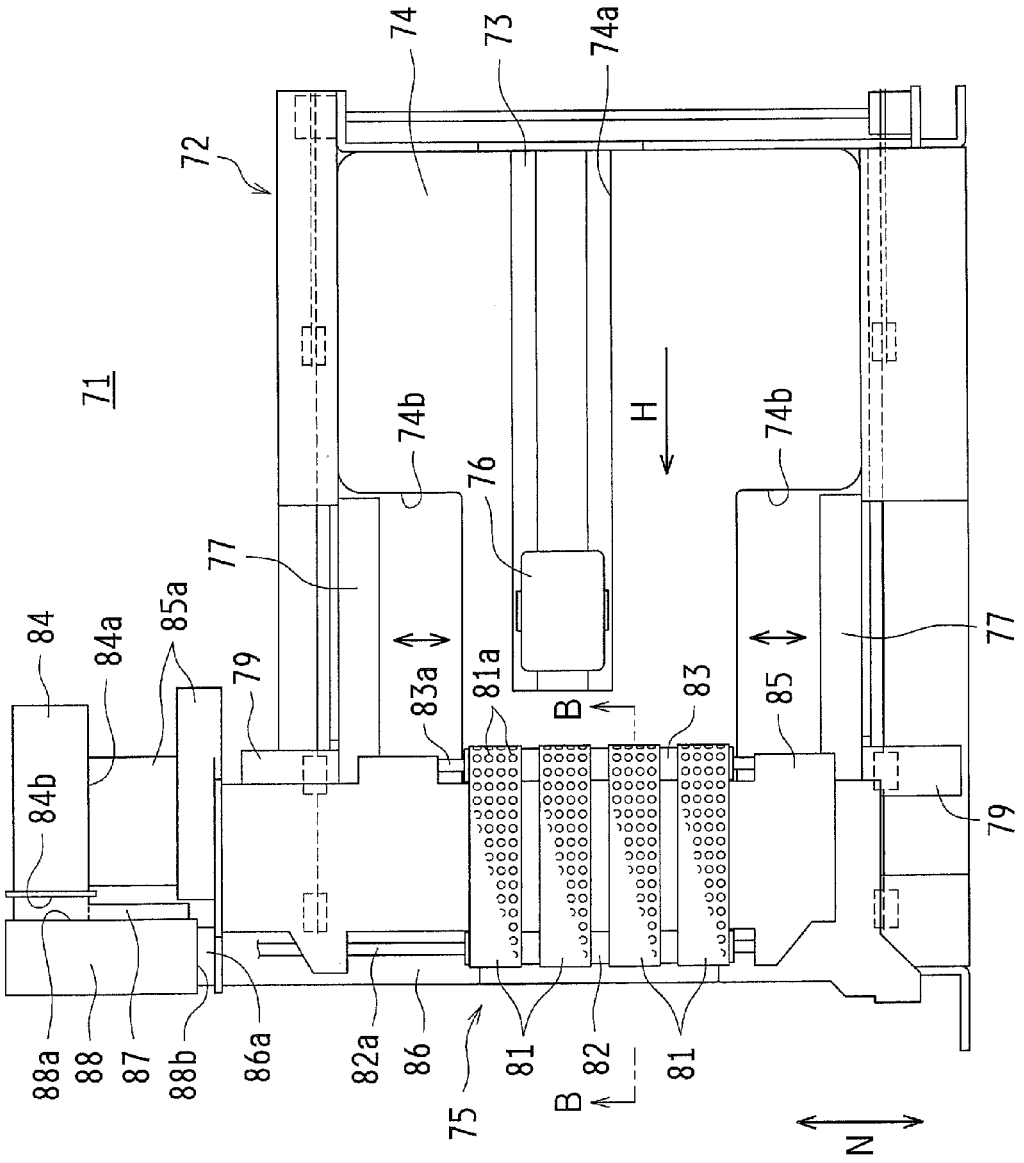
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FIG.2

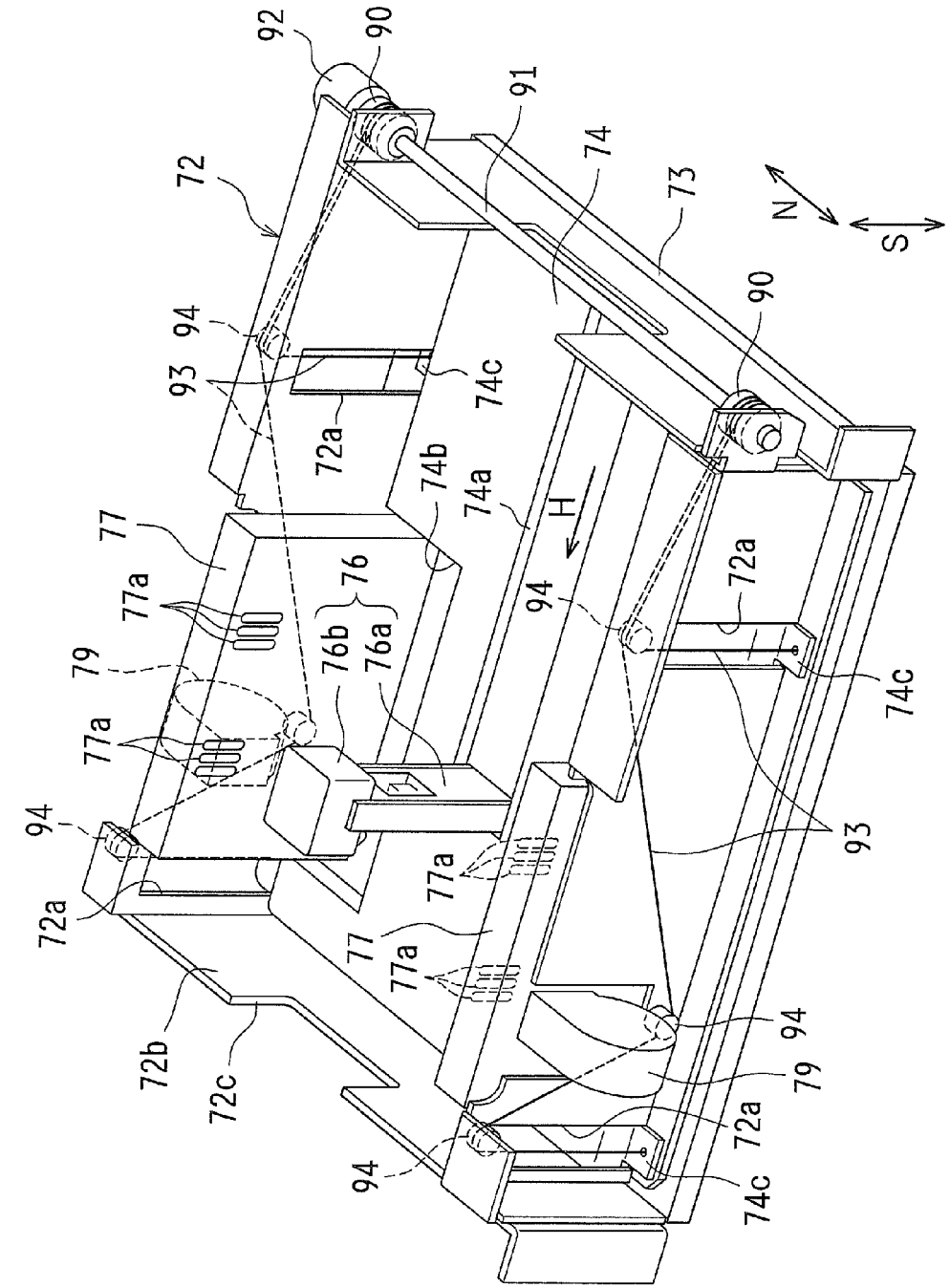
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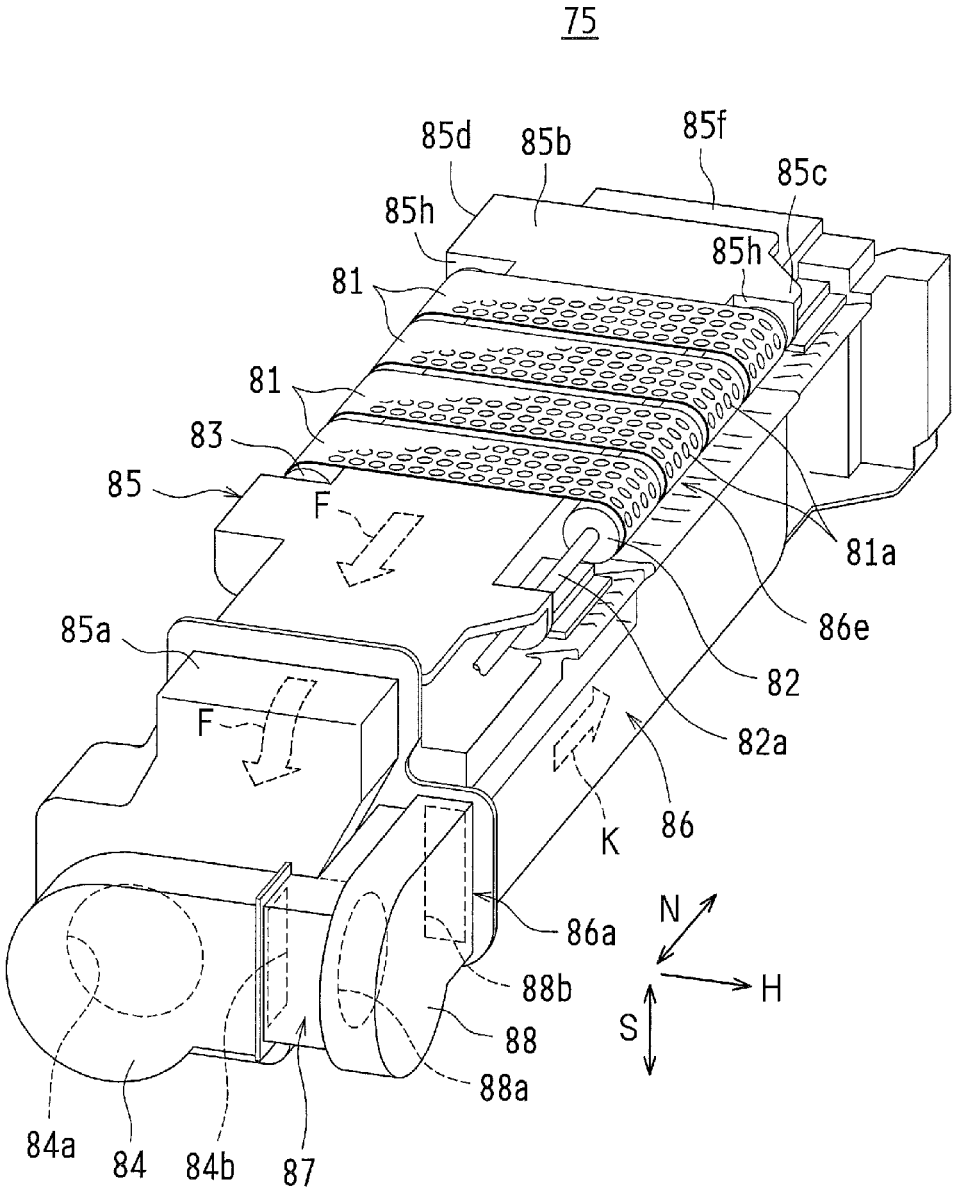
FIG.3

FIG.4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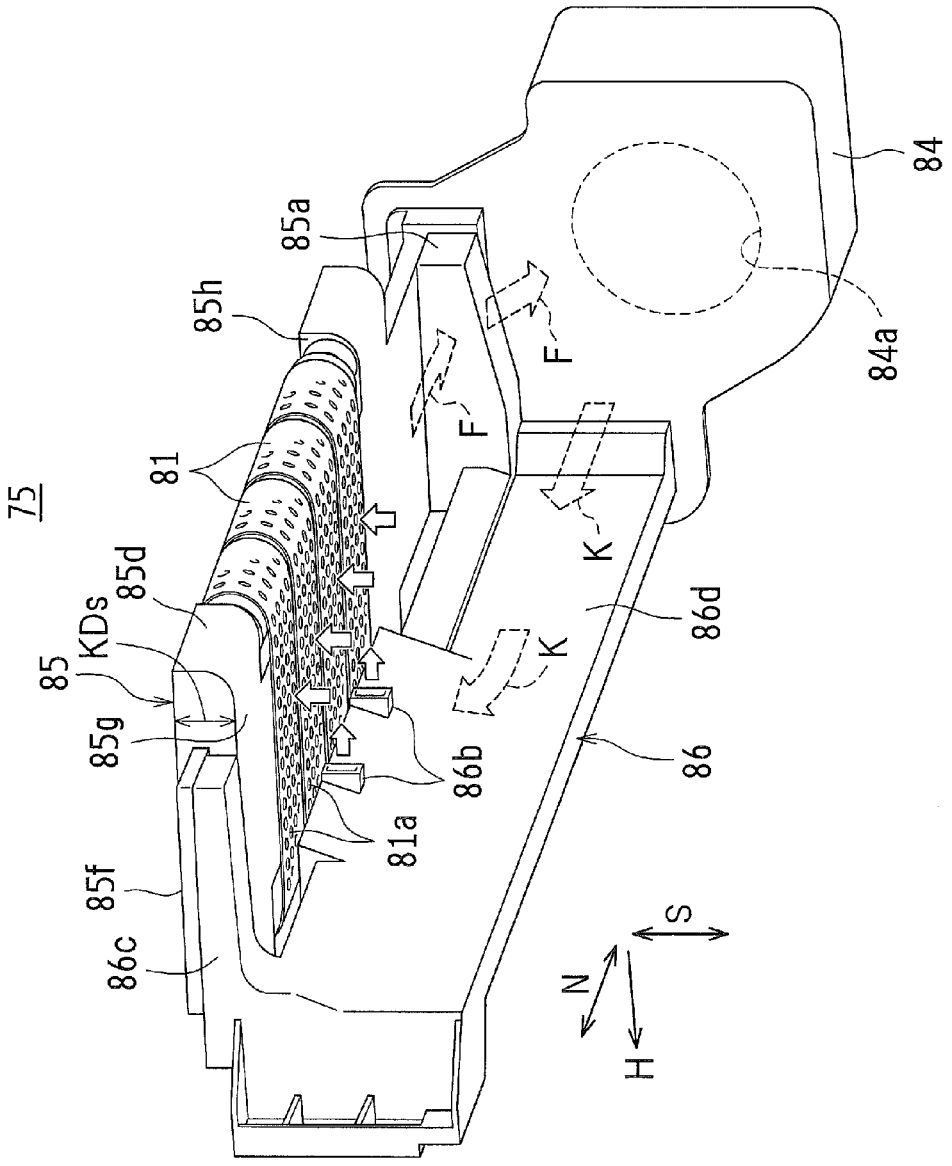

FIG.5

FIG.6

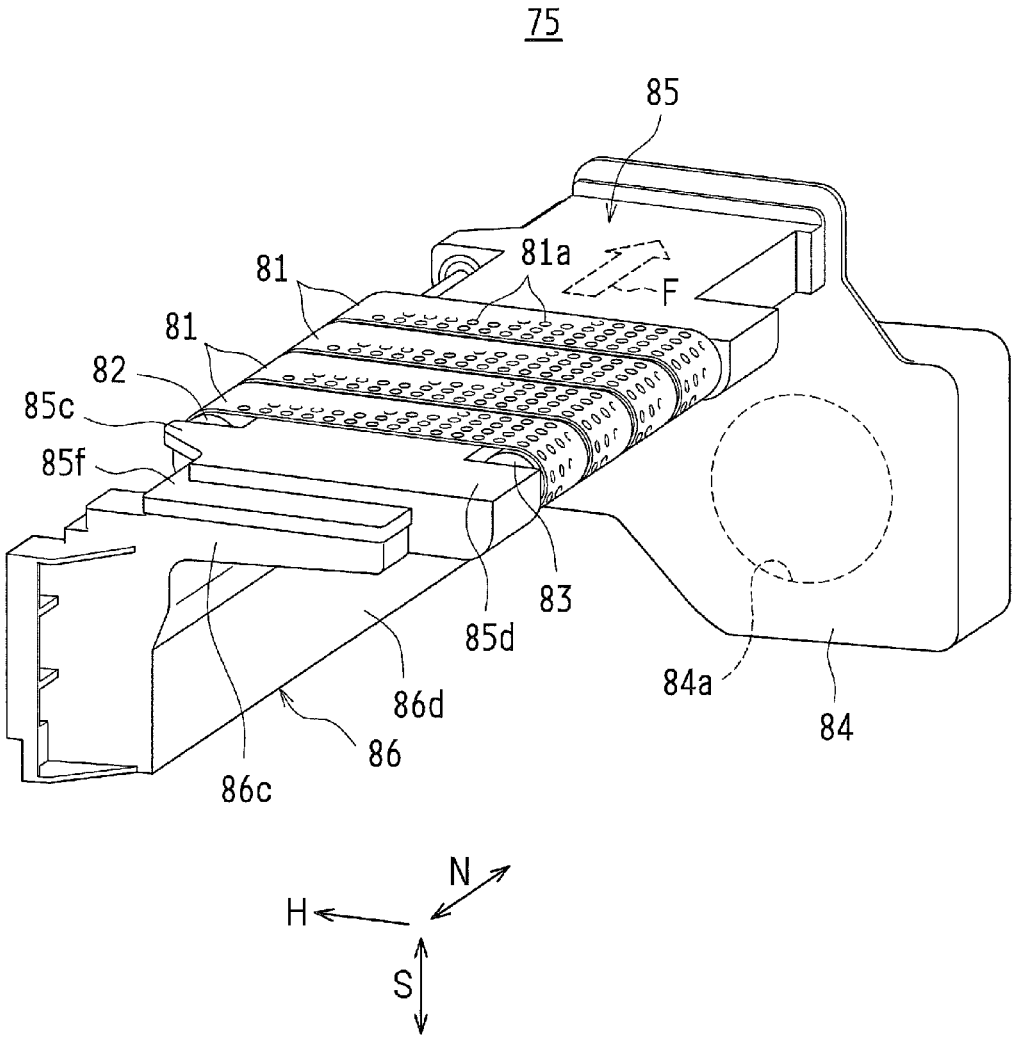

FIG.7

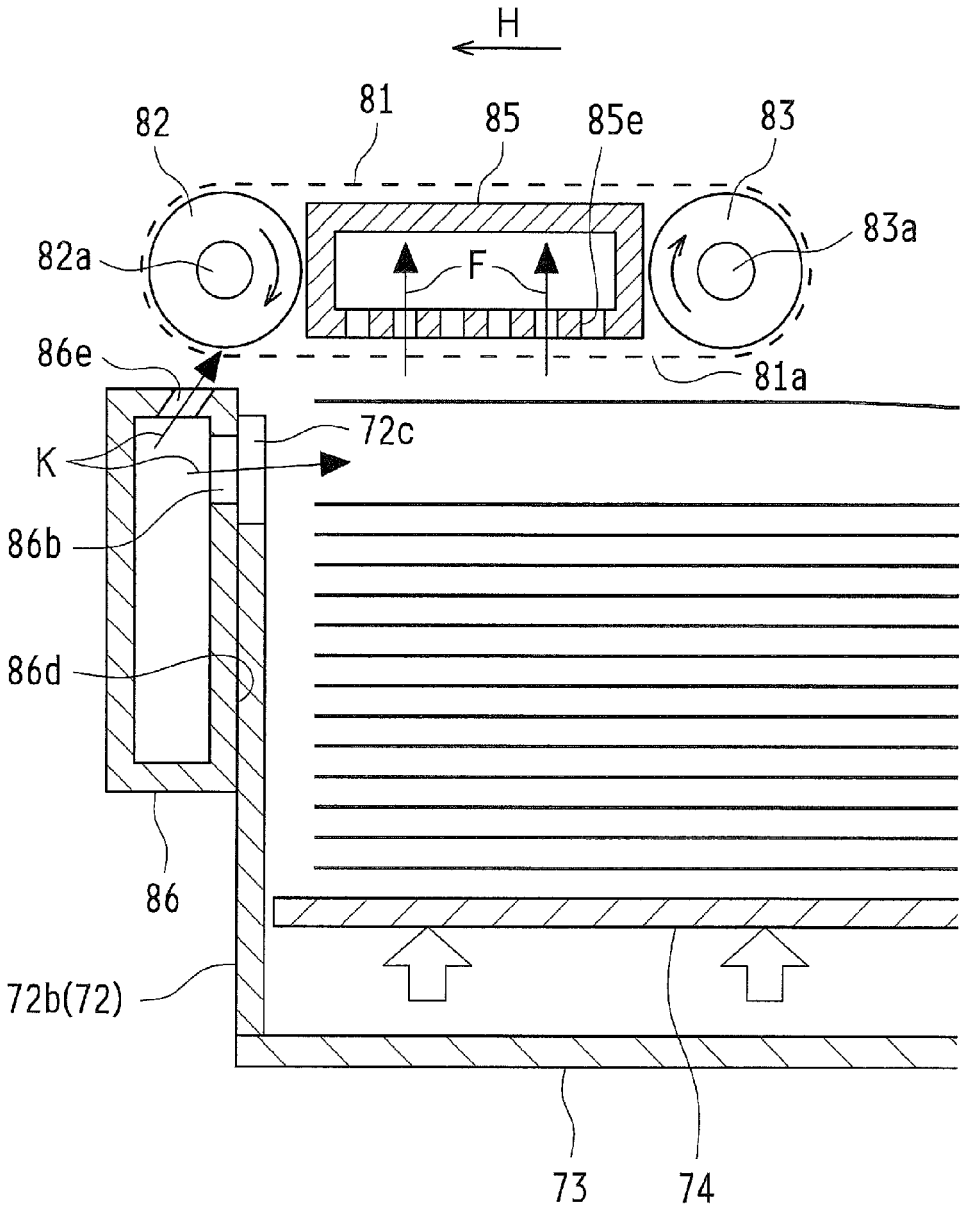

FIG.8A

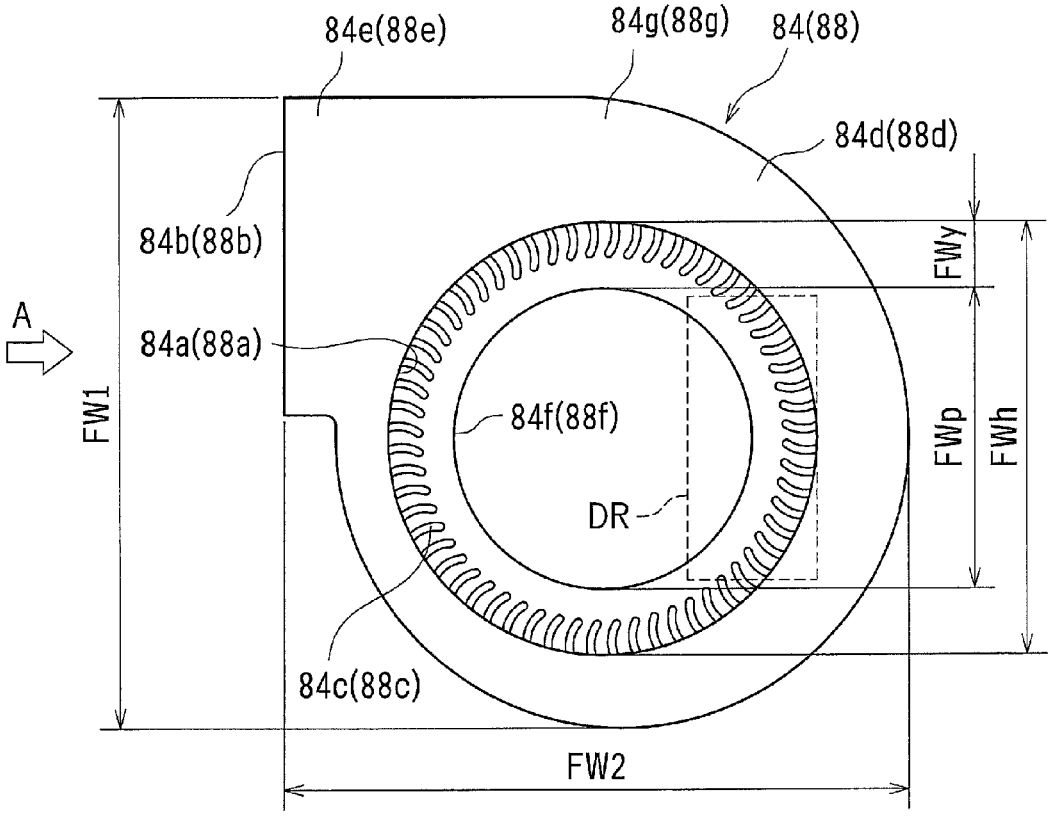
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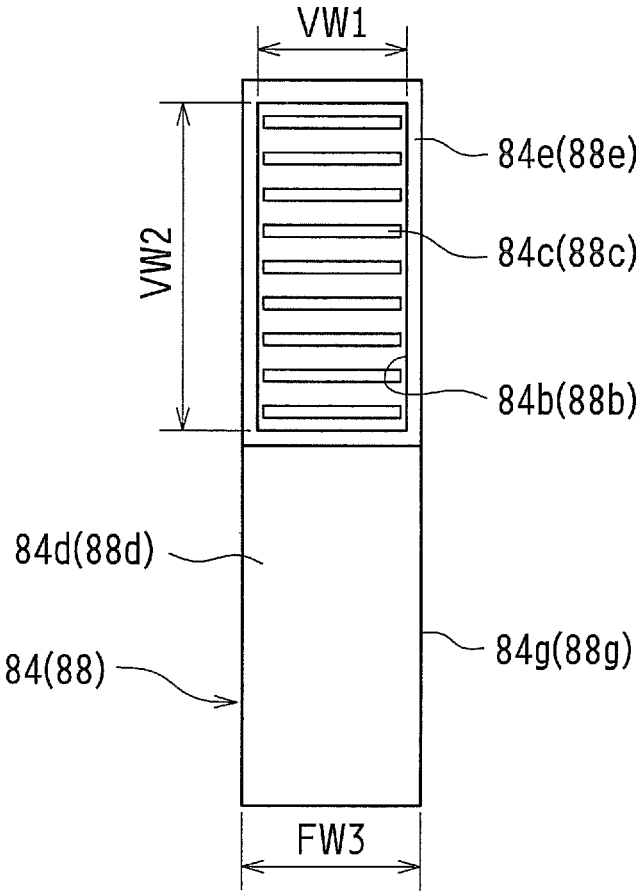
FIG.8B



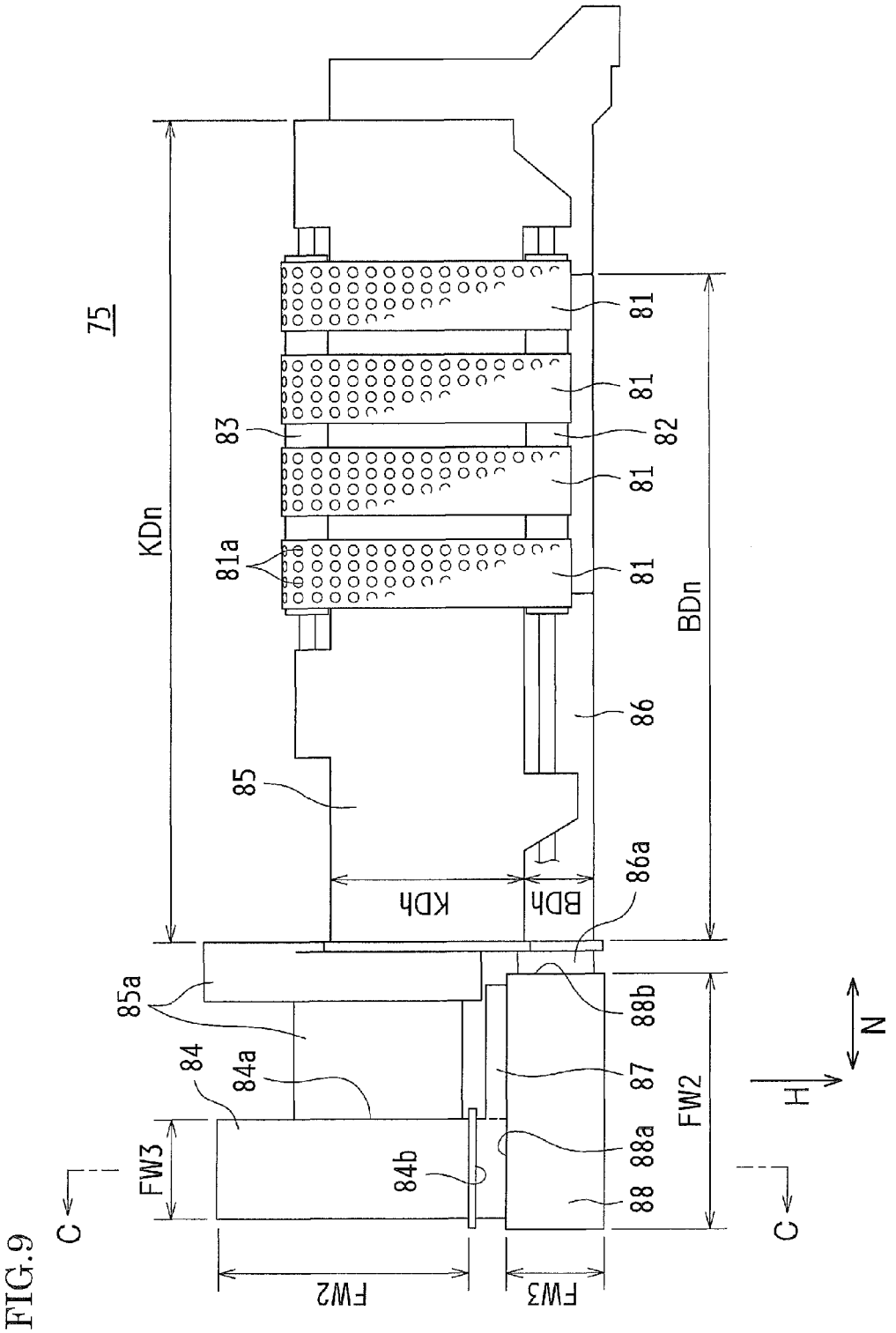

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FIG.9

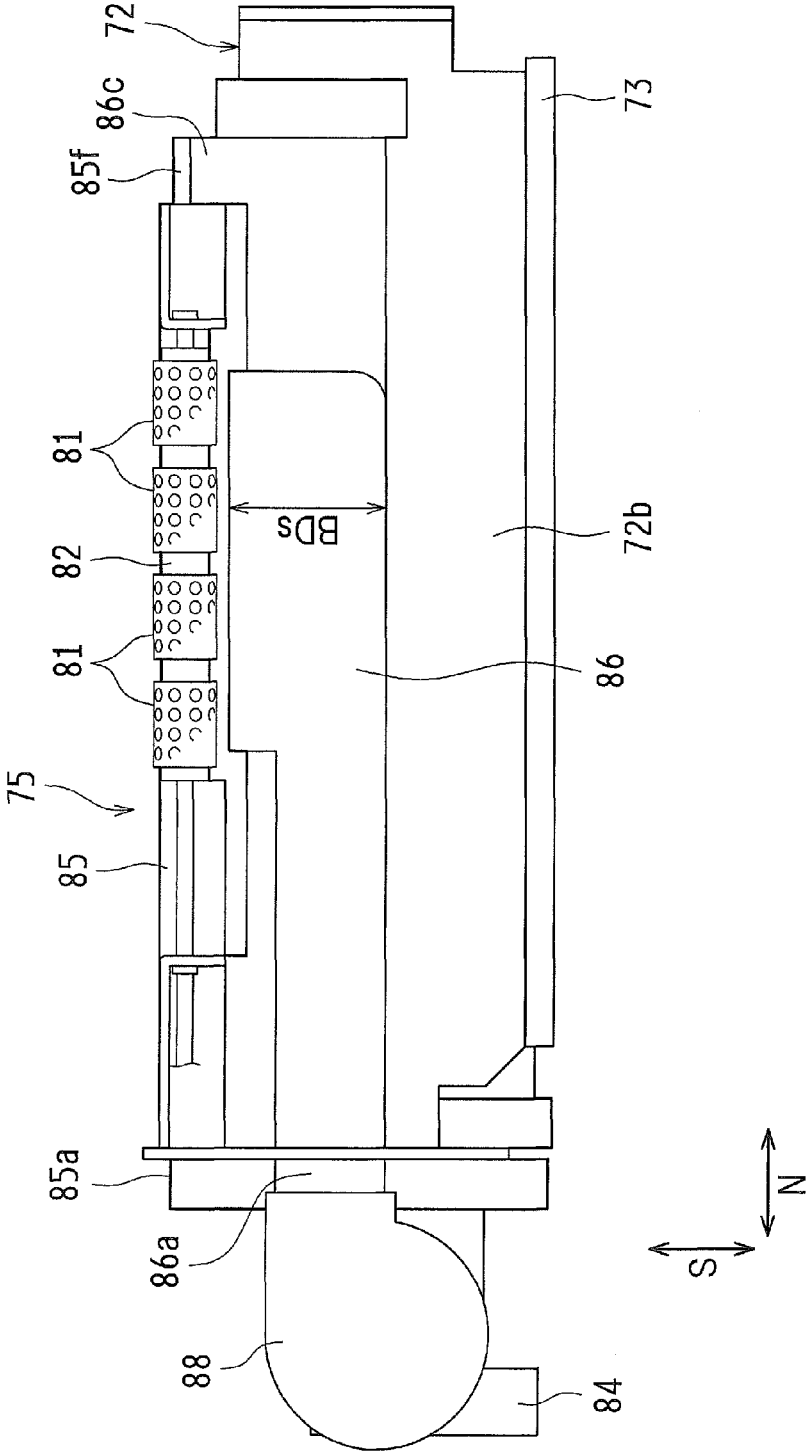

FIG.10

FIG.11

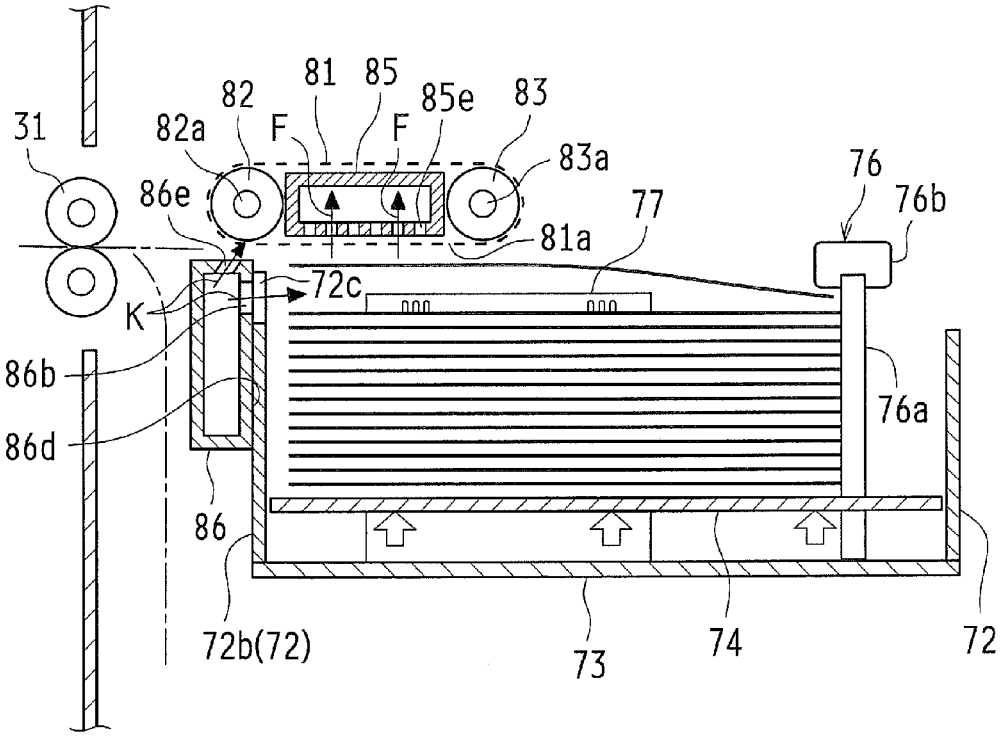
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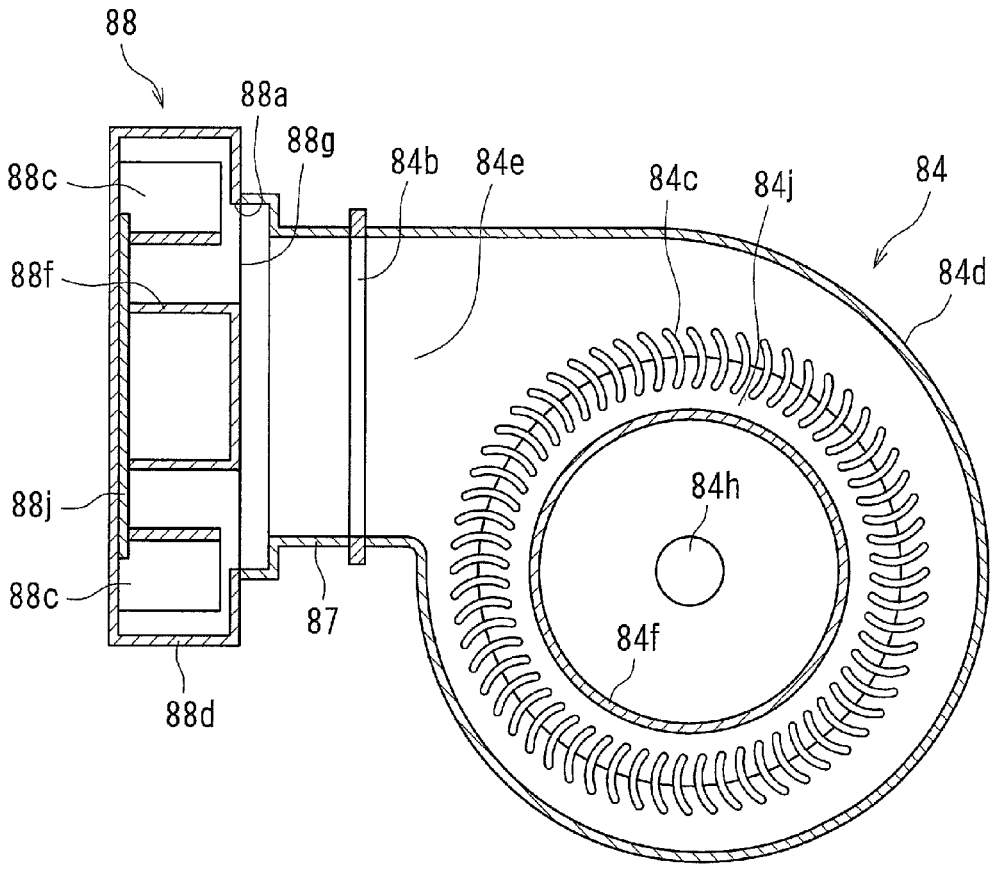
FIG.12



PAPER FEEDING DEVICE AND IMAGE FORMING DEVICE

This application is the U.S. national phase of International Application No. PCT/JP2012/083115 filed 20 Dec. 2012 which designated the U.S. and claims priority to JP 2012-014921 filed 27 Jan. 2012, and JP 2012-014922 filed 27 Jan. 2012, the entire contents of each of which are hereby incorporated by reference.

TECHNICAL FIELD

The present invention relates to paper feeding devices equipped with a paper transport member for transporting printing paper stacked on a paper stacking tray by sucking the printing paper and also relates to image forming devices equipped with such a paper feeding device.

BACKGROUND ART

Conventional printers, copying machines, and like image forming devices include a paper feeding device that removes, a sheet at a time, printing paper from a stack on a paper feed tray to feed the sheets individually to an image forming section. The paper feeding device employs one of various mechanisms, such as separation claws, friction pads, and gating, to remove printing paper, a sheet at a time, from a paper feed tray. Many other mechanisms have been also developed by which air is blown at printing paper so that individual sheets can be levitated and separated.

An air blowing device that includes an air blowing fan and an air sucking fan is discussed as a type of paper feeding device that blows air for paper separation (see, for example, Patent Document 1). In the paper feeding device of Patent Document 1, the air blowing fan separates printing paper on a paper feed tray by blowing air at the printing paper. The air sucking fan then draws the separated sheet of printing paper onto a paper feeding belt via an air inlet. The air blowing device is enclosed in a shield member provided with the air inlet to block unwanted noise generated by the air blowing device.

Another type of paper feeding device is discussed which reshapes each sheet of printing paper to be drawn onto a transport belt into an arch form to achieve improved printing paper separation (see, for example, Patent Document 2). In the paper feeding device of Patent Document 2, an air blowing fan blows air at printing paper, and an air sucking fan draws the printing paper onto a transport belt via an air sucking duct that has an air sucking port on its bottom wall. The transport belt is curved by a rib standing out of the bottom wall of the air sucking duct so that the printing paper drawn onto the transport belt is reshaped into an arch form. This mechanism provides an air passage between the printing paper drawn onto the transport belt and the printing paper on a paper feed plate.

These paper feeding devices use a single fan as both the air sucking fan and the air blowing fan. Another type of paper feeding device is discussed which includes two fans that are coupled together (see, for example, Patent Documents 3 and 4).

In the paper feeding device of Patent Document 3, the air outlet of one of the fans and the air inlet of the other fan is linked by a coupling passage so that the two fans can suck in air to draw a sheet of printing paper onto a transport belt. The air blown out of the air outlet of the other fan is aimed at a printing paper storage section on which there is provided a paper feed tray. The paper feeding device levitates and separates printing paper by a levitation air blowing mechanism that blows air at a side face of the stack of printing paper on the paper feed tray and a separation air blowing mechanism that blows air at the front of the printing paper drawn onto the transport belt. The air sucking forces of the individual fans are added up by positioning the two fans in series, to generate a sufficient drawing force.

In the media feeding device of Patent Document 4, there is provided air supply means in which the air outlet of an upstream fan is coupled to the air outlet of the downstream fan via a spiral channel. The air supply means blows air to levitate several sheets from the stack of sheets on a sheet tray. Above the stack of sheets is there also provided suction/transport means including a suction fan that sucks in air to draw the sheet levitated from the sheet tray onto a transport belt. The two coupled fans generate high-pressure air to unfailingly separate and levitate sheets.

CITATION LIST

Patent Literature

Patent Document 1: Japanese Patent Application Publication, Tokukaihei, No. 11-157678

Patent Document 2: Japanese Patent Application Publication, Tokukai, No. 2001-39556

Patent Document 3: Japanese Patent Application Publication, Tokukai, No. 2010-215350

Patent Document 4: Japanese Patent Application Publication, Tokukai, No. 2007-261719

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

Fans used in a paper feeding device need to generate strong air sucking force to unfailingly separate and levitate printing paper. For greater air sucking force, physically larger fans should be used, as an example. However, a physically large fan disadvantageously could not operate on the same power source as the image forming device.

A first issue for the present invention is related to air sucking force for printing paper.

Fans used in a paper feeding device need to generate strong air sucking force to unfailingly separate and levitate printing paper. For greater air sucking force, physically larger fans should be used, as an example. However, a physically large fan disadvantageously could not operate on the same power source as the image forming device.

In the paper feeding device of Patent Document 1, the air blowing device drives two fans with a single blower motor. Therefore, the air blowing device disadvantageously needs a dedicated power source similarly to a physically large fan. Another problem is that sufficient air sucking force is not available because the air sucking fan and the air blowing fan are independently provided.

The paper feeding device of Patent Document 2 has the same problem: sufficient air sucking force is not available because the air sucking fan and the air blowing fan are independently provided.

In the paper feeding device of Patent Document 3, the air inlet is provided along the axis of the blade wheel, and the air outlet is provided along a tangent to the blade wheel. The two fans are stacked vertically with their air inlets looking upwards. Since the air outlet of one of the fans and the air inlet of the other fan are provided in different directions, the coupling passage needs to have a bend to link the two fans. In the

bend, the wall face and other obstacles disrupt an air flow, causing a loss in the air flow. This structure of the paper feeding device hence inevitably has a problem that the air sucking force decreases as air flows through the coupling passage. The paper feeding device needs a fan to levitate printing paper in addition to the fans linked in series.

In the media feeding device of Patent Document 4, two fans are linked by a spiral channel in which the wall face and other obstacles change the direction of an air flow, inevitably resulting in a problem that the wind pressure decreases as air passes through the spiral channel. The media feeding device needs a suction fan in addition to the fans linked by the spiral channel.

The present invention, in view of the first issue, has an object to provide a paper feeding device and an image forming device that are capable of mutually reinforcing the force that draws printing paper and the force that separates printing paper by connecting an air sucking fan and a separation fan.

A second issue for the present invention is related to reduction of the image forming device in size.

The paper feeding device needs to be reduced further in size to realize a more compact image forming device with higher functionality. For these purposes, it is proposed to reduce the size of the housing by reducing the footprint of the paper feeding device and to add more components.

In the paper feeding device of Patent Document 1, the air blowing device is covered with a shield member, and a shield plate is provided inside the shield member. The structure requires a large space around the air blowing device, which hampers easy size reduction.

In the paper feeding device of Patent Document 2, sufficient air sucking force is not available because the air sucking fan and the air blowing fan are independently provided.

The paper feeding device of Patent Document 3 needs a fan to levitate printing paper in addition to the fans linked in series. Therefore, the paper feeding device needs a sufficient space to accommodate the three fans, which again hampers easy size reduction.

The media feeding device of Patent Document 4 needs a suction fan in addition to the fans linked by the spiral channel. Therefore, the media feeding device needs a sufficient space to accommodate the three fans, which again hampers easy size reduction.

None of Patent Documents 1 to 4 discusses correlation between the shape of the fans and the shape of the duct that constitutes an air channel in reducing the size of the paper feeding device.

The present invention, in view of the second issue, has an object to provide a paper feeding device and an image forming device that are capable of allowing for size reduction by reducing the width in a longitudinal direction and the width in a transport direction as much as possible.

Solution to Problem

A paper feeding device in accordance with a first aspect of the present invention includes: a paper stacking tray that carries thereon stacked sheets of printing paper and moves up/down along a stacking direction of the sheets of printing paper; a paper transport member that sucks in air to suck and transport a sheet of printing paper stacked on the paper stacking tray; a separation fan that generates an air flow separating the printing paper stacked on the paper stacking tray; an air sucking fan that generates an air flow sucking the sheet of printing paper stacked on the paper stacking tray; and a relay duct that guides air coming out of the air sucking fan to the separation fan, wherein the relay duct extends along a straight line from an air outlet of the air sucking fan to an air inlet of the separation fan.

According to the structure, an air sucking fan and a separation fan are connected so that one of the fans can compensate for insufficiency of the air generated by the other fan. The fans thus mutually reinforce the force that draws printing paper and the force that separates printing paper. In other words, the air sucking fan not only exerts a force that draws (sucks) printing paper, but also exerts a force that separates printing paper, whereas the separation fan not only exerts a force that separates printing paper, but also exerts a force that draws printing paper. Forming a relay duct along a straight line eliminates wall faces and other obstacles from its structure, reducing loss of an air flow during its passage in the relay duct. Using a fewer fans allows for a more compact, less power-consuming paper feeding device.

Preferably, the paper feeding device in accordance with the present invention further includes a separation duct that, connected to an air outlet of the separation fan, constitutes a channel for air separating the printing paper, wherein the relay duct and the separation duct are coupled at a predetermined angle, and the separation fan is disposed where the relay duct and the separation duct are coupled.

This structure changes the direction of the air that flows through the separation fan and provides a separation duct along the air flow coming from the separation fan. That in turn reduces the loss that would otherwise be caused by wall faces and other obstacles, thereby achieving efficient printing paper separation.

Preferably, in the paper feeding device in accordance with the present invention, the predetermined angle is equal to 90°.

According to the structure, the relay duct and the separation duct are coupled at a 90° angle. That enables air to be fed normal to the air inlet of the separation fan. The separation fan hence collects air efficiently.

Preferably, the paper feeding device in accordance with the present invention further includes an air sucking duct that, connected to an air inlet of the air sucking fan, constitutes a channel for air sucking a sheet of printing paper, wherein the air sucking duct sucks in air coming out of the separation duct.

According to the structure, the air sucking duct sucks in part of the air coming out of the separation duct to form an air channel between the separation duct and the air sucking duct. This enables an air circulation in the paper feeding device, which reduces loss of an air flow for efficient operation.

Preferably, in the paper feeding device in accordance with the present invention, the relay duct has an opening that faces blades of the separation fan.

According to the structure, the air coming out of the relay duct directly hits the blades of the separation fan, which enables efficient feeding of air to the separation fan.

Preferably, in the paper feeding device in accordance with the present invention, the air outlet of the air sucking fan is disposed at such a position that the air outlet of the air sucking fan overlaps a part of an air sucking region from which the separation fan sucks in air and that an area in which the air outlet of the air sucking fan overlaps the air sucking region is maximized.

According to the structure, the separation fan sucks in as much of the air coming out of the air sucking fan as possible. That in turn increases the air coming out of the separation fan.

Preferably, in the paper feeding device in accordance with the present invention, the air sucking region is shaped like a circular ring, and the air outlet of the air sucking fan is rectangular, when viewed normal to a plane in which the air

inlet of the separation fan lies, and one of sides of a projection of the air outlet of the air sucking fan onto the separation fan matches a tangent to an external circle of the air sucking region.

The structure specifies the position of the air outlet of the air sucking fan. That in turn facilitates designing of a structure that maximizes the area in which the air outlet of the air sucking fan overlaps the air sucking region.

A paper feeding device in accordance with a second aspect of the present invention includes: a paper stacking tray that carries thereon stacked sheets of printing paper and moves up/down along a stacking direction of the sheets of printing paper; a paper transport member that sucks in air to suck and transport a sheet of printing paper stacked on the paper stacking tray; letting a longitudinal direction be along a front end of the printing paper stacked on the paper stacking tray, a separation duct that, disposed facing the front end of the printing paper stacked on the paper stacking tray, constitutes a channel for air separating the printing paper; a separation fan that, coupled to an end of the separation duct with respect to the longitudinal direction, generates an air flow separating the printing paper stacked on the paper stacking tray; an air sucking duct that, disposed in the longitudinal direction facing a top face of the printing paper stacked on the paper stacking tray, constitutes a channel for air sucking the sheet of printing paper stacked on the paper stacking tray; and an air sucking fan that, coupled to an end of the air sucking duct with respect to the longitudinal direction, generates an air flow sucking the sheet of printing paper stacked on the paper stacking tray, wherein the air sucking fan is disposed so that a longitudinal direction of the air sucking duct matches a minimum width direction of the air sucking fan, the separation duct is disposed so that the longitudinal direction of the air sucking duct is along a longitudinal direction of the separation duct and that a transport direction of the printing paper matches a minimum width direction of the separation duct, and the separation fan is disposed so that the minimum width direction of the separation duct is along a minimum width direction of the separation fan.

According to the structure, the minimum width direction of the air sucking fan matches the longitudinal direction of the air sucking duct. That reduces the width of the paper drawing section constituted by the ducts and fans in the longitudinal direction. The matching of the minimum width directions of the separation duct and the separation fan with the transport direction reduces the width of the paper drawing section in the transport direction. Reducing the widths in the longitudinal and transport directions to possible minimums allows for reduction of the paper feeding device in size. Providing the coupled air sucking fan and separation fan mutually reinforces the force that draws printing paper and the force that separates printing paper.

Preferably, in the paper feeding device in accordance with the present invention, the separation fan has an air outlet in a plane normal to the longitudinal direction, the air outlet of the separation fan being wider in the stacking direction than in the transport direction.

According to the structure, the air outlet of the separation fan is wider in the stacking direction, which ensures a sufficient cross-sectional area for the channel. Since the separation fan and the separation duct have their minimum width directions matched with the transport direction, the separation fan and the separation duct are not allowed to have an increased width in the transport direction. The widths can however be readily increased in the stacking direction in which a predetermined area is ensured for the provision of the paper stacking tray.

Preferably, in the paper feeding device in accordance with the present invention, the air sucking fan has an air outlet in a plane normal to the transport direction, the air outlet of the air sucking fan being wider in the stacking direction than in the longitudinal direction.

According to the structure, the air outlet of the air sucking fan is wider in the stacking direction, which ensures a sufficient cross-sectional area for the channel. Since the air sucking fan has its minimum width direction matched with the longitudinal direction of the air sucking duct, the air sucking fan is not allowed to have an increased width in the longitudinal direction. The width can however be readily increased in the stacking direction in which a predetermined area is ensured for the provision of the paper stacking tray.

Preferably, the paper feeding device in accordance with the present invention further includes a relay duct that guides air coming out of the air sucking fan to the separation fan, wherein the relay duct and the separation duct are coupled at a predetermined angle, and the separation fan is disposed where the relay duct and the separation duct are coupled.

This structure changes the direction of the air that flows through the separation fan and provides a separation duct along the air flow coming from the separation fan. That in turn reduces the loss that would otherwise be caused by wall faces and other obstacles, thereby achieving efficient printing paper separation.

Preferably, in the paper feeding device in accordance with the present invention, the predetermined angle is equal to 90°.

According to the structure, the relay duct and the separation duct are coupled at a 90° angle. That enables air to be fed normal to the air inlet of the separation fan. The separation fan hence collects air efficiently.

Preferably, in the paper feeding device in accordance with the present invention, the relay duct has an opening that faces blades of the separation fan.

According to the structure, the air coming out of the relay duct directly hits the blades of the separation fan, which enables efficient feeding of air to the separation fan.

Preferably, in the paper feeding device in accordance with the present invention, the air sucking fan and the separation fan have a common structure.

According to the structure, the air sucking fan is identical to the separation fan, which facilitates reduction of unwanted noise generated by the fans. Since the fans have approximately equal rotational speeds and cycles, the frequencies of their unwanted noise are confined to a narrow range of frequencies. The noise can be thus reduced without addressing a wide range of frequencies.

Preferably, in the paper feeding device in accordance with the present invention, the separation fan generates a higher wind pressure than does the air sucking fan.

According to the structure, the separation fan generates an increased wind pressure, which compensates for the loss that occurs during passage in the relay duct. A longer channel inevitably lowers the wind pressure, albeit slightly. An output difference between the fans ensures a consistent wind pressure.

An image forming device in accordance with the present invention includes a paper feeding device in accordance with the present invention.

According to the structure, the image forming device, including a paper feeding device in accordance with the present invention, achieves the same functions and effects as the paper feeding device in accordance with the present invention.

Advantageous Effects of the Invention

First effects of the present invention are that connecting the air sucking fan and the separation fan enables one of the fans

to compensate for insufficiency of the air generated by the other fan, the fans thus mutually reinforcing the force that draws printing paper and the force that separates printing paper. In other words, the air sucking fan not only exerts a force that draws printing paper, but also exerts a force that separates printing paper, whereas the separation fan not only exerts a force that separates printing paper, but also exerts a force that draws printing paper. Forming a relay duct along a straight line eliminates wall faces and other obstacles from its structure, reducing loss of an air flow during its passage in the relay duct. Using a fewer fans allows for a more compact, less power-consuming paper feeding device.

Second effects of the present invention are that matching the minimum width direction of the air sucking fan and the longitudinal direction of the air sucking duct reduces the width of the paper drawing section constituted by the ducts and fans in a longitudinal direction. The matching of the minimum width directions of the separation duct and the separation fan with the transport direction reduces the width of the paper drawing section in the transport direction. Reducing the widths in the longitudinal and transport directions to possible minimums allows for reduction of the paper feeding device in size. Providing the coupled air sucking fan and separation fan mutually reinforces the force that draws printing paper and the force that separates printing paper.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic side view of an image forming device in accordance with an embodiment of the present invention.

FIG. **2** is a plan view of a paper feeding device in accordance with an embodiment of the present invention.

FIG. **3** is a perspective view of an outer frame assembly, a bottom plate, and a paper stacking tray, with a paper drawing section being removed.

FIG. **4** is a perspective view of the paper drawing section as viewed obliquely downward from the front.

FIG. **5** is a perspective view of the paper drawing section as viewed obliquely upward from the rear.

FIG. **6** is a perspective view of the paper drawing section as viewed obliquely downward from the rear.

FIG. **7** is an enlarged cross-sectional view primarily showing the paper drawing section as taken according to arrows B-B shown in FIG. **2**.

FIG. **8**A is a front view of only an air sucking fan and a separation fan.

FIG. **8**B is a side view of the air sucking fan and the separation fan as viewed from the direction indicated by arrow A in FIG. **8**A.

FIG. **9** is a plan view of the removed paper drawing section.

FIG. **10** is a side view of the paper feeding device shown in FIG. **2**.

FIG. **11** is a simplified cross-sectional view of a paper feeding device in accordance with an embodiment of the present invention.

FIG. **12** is a cross-sectional view taken according to arrows C-C in FIG. **9**.

DESCRIPTION OF EMBODIMENTS

The following will describe an image forming device in accordance with an embodiment of the present invention in reference to drawings.

FIG. **1** is a schematic side view of an image forming device in accordance with an embodiment of the present invention.

An image forming device **1** includes an original reading section **2**, an image forming section **11**, a paper transport section **12**, a paper supply section **13**, and a large capacity paper feeding cassette (large capacity cassette, or LCC) **14**, to form an image represented by image data on printing paper. The image forming device **1** generates image data by capturing an original document image in the original reading section **2** or receives image data from, for example, an external terminal device. The image forming device **1** subjects the obtained image data to various image processing and forms an image represented by the resultant image data on printing paper in the image forming section **11**.

The original reading section **2**, disposed above the image forming section **11**, includes an optical reading section **41** (bottom) and an original document transport section **42** (top).

The optical reading section **41** includes an original document tray **44** and an original reading glass on top thereof and a light source **51** and a solid-state image capturing element **48** inside thereof. The original document tray **44** and the original reading glass are made of transparent glass. The front side of an original document placed either on the original document tray **44** or on the original reading glass is illuminated by a light source **51**. Reflected light is guided to the solid-state image capturing element **48** via reflective mirrors, lenses, etc. The solid-state image capturing element **48** generates image data based on incoming reflected light.

The original document transport section **42** automatically transports the original document onto the original reading glass. The original document transport section **42** is structured so that it can pivot freely around an axis that couples the image forming section **11** and the original document transport section **42**. Hence, an original document may be manually placed when the top of the original document tray **44** is opened.

The image forming section **11** includes a photosensitive drum **21** and a fusing device **27** on a transport path **33**. Around the photosensitive drum **21** are there disposed a charger device **22**, a laser emission device **23**, a developer device **24**, a transfer roller **25**, and a cleaning device **26**.

The photosensitive drum **21** has a photosensitive layer on its surface and rotates as indicated by an arrow. The surface of the photosensitive drum **21** is cleaned by the cleaning device **26** before uniformly charged to a predetermined electric potential by the charger device **22**. The laser emission device **23** is a laser scanning unit (LSU) including a laser diode and reflective mirrors. The laser emission device **23** scans the surface of the photosensitive drum **21** with a laser beam and writes an electrostatic latent image on the surface of the photosensitive drum **21** according to incoming image data. The developer device **24** develops the electrostatic latent image written on the surface of the photosensitive drum **21** with toner to form a toner image on the surface of the photosensitive drum **21**.

The transfer roller **25** is brought into contact with the photosensitive drum **21** under pressure to form a nip region between the transfer roller **25** and the photosensitive drum **21** and rotates together with the photosensitive drum **21**. The photosensitive drum **21** and the transfer roller **25** transport incoming printing paper that has been transported via the transport path **33**, by nipping the printing paper in the nip region, and transfer the toner image on the surface of the photosensitive drum **21** onto the printing paper. The printing paper onto which the toner image has been transferred is transported to the fusing device **27** via the transport path **33**.

The fusing device **27** nips printing paper, for example, between rollers to apply heat and pressure while the printing paper is passing therethrough, to fuse the toner image trans-

ferred onto the printing paper. Thereafter, the printing paper is ejected via discharge rollers **36** and stacked on the discharge tray **37**.

The paper transport section **12** includes transport rollers **31**, registration rollers **32**, a transport path **33**, a bypass path **34**, a branch claw **35**, discharge rollers **36**, and a discharge tray **37**.

The paper supply section **13** includes paper feeding cassettes **38**. Each paper feeding cassette **38** includes, for example, pickup rollers **39** to draw out and send the printing paper, a sheet at a time, down the transport path **33**.

The large capacity paper feeding cassette **14** includes a paper feeding device **71** that contains stacked sheets of printing paper. The paper feeding device **71** draws out and sends the printing paper, a sheet at a time, down the transport path **33**. Details will be given later about the paper feeding device **71** in reference to FIG. **2**.

In the image forming device **1**, the printing paper is transported by the transport rollers **31** via the transport path **33** and ejected onto the discharge tray **37** via the transfer roller **25** and the fusing device **27**. In the transport path **33**, the printing paper is temporarily stopped by the registration rollers **32** disposed before the photosensitive drum **21**. After that, the printing paper is transported at a proper transfer timing in view of the toner image on the surface of the photosensitive drum **21**.

If an image is to be formed on the backside of the printing paper after an image is formed on the front side, the branch claw **35** is switched in such a manner as to transport the printing paper in the opposite direction from the discharge rollers **36** to the bypass path **34**. The printing paper is turned over in the bypass path **34** and again guided to the registration rollers **32** to form an image on the backside of the printing paper in the same manner as on the front side before discharging the printing paper onto the discharge tray **37**.

Next, a paper feeding device in accordance with an embodiment of the present invention will be described in reference to drawings.

FIG. **2** is a plan view of a paper feeding device in accordance with an embodiment of the present invention.

A paper feeding device **71** in accordance with an embodiment of the present invention includes a paper stacking tray **74**, a paper transport member (e.g., paper transport belts **81**), a separation fan **88**, an air sucking fan **84**, and a relay duct **87**. The paper stacking tray **74** carries thereon stacked sheets of printing paper and moves up/down along a stacking direction, S, of the sheets of printing paper (see FIG. **3** which will be described later in detail). The paper transport member sucks in air to suck and transport a sheet of printing paper stacked on the paper stacking tray **74**. The separation fan **88** generates an air flow separating the printing paper stacked on the paper stacking tray **74**. The air sucking fan **84** generates an air flow sucking a sheet of printing paper stacked on the paper stacking tray **74**. The relay duct **87** guides the air coming out of the air sucking fan **84** to the separation fan **88**. The relay duct **87** extends along a straight line from an air outlet **84***b* of the air sucking fan **84** to an air inlet **88***a* of the separation fan **88**.

According to the structure, the air sucking fan **84** and the separation fan **88** are connected so that one of the fans can compensate for insufficiency of the air generated by the other fan. The fans thus mutually reinforce the force that draws printing paper and the force that separates printing paper. In other words, the air sucking fan **84** not only exerts a force that draws printing paper, but also exerts a force that separates printing paper, whereas the separation fan **88** not only exerts a force that separates printing paper, but also exerts a force that draws printing paper. Forming the relay duct **87** along a straight line eliminates wall faces and other obstacles from its structure, reducing loss of an air flow during its passage in the relay duct **87**. Using a fewer fans allows for a more compact, less power-consuming paper feeding device.

The paper feeding device **71** includes an air sucking duct **85** that, connected to an air inlet **84***a* of the air sucking fan **84**, constitutes a channel for air sucking a sheet of printing paper and a separation duct **86** that, connected to an air outlet **88***b* of the separation fan **88**, constitutes a channel for air separating the printing paper.

As illustrated in FIG. **2**, the paper feeding device **71** includes an outer frame assembly **72**, a bottom plate **73**, a paper stacking tray **74**, and a paper drawing section **75**. The paper drawing section **75** is disposed above an edge of the outer frame assembly **72** and constituted by four paper transport belts **81**, a set of rollers **82** and **83** around which the paper transport belts **81** are stretched, the air sucking duct **85**, the air sucking fan **84**, the relay duct **87**, the separation fan **88**, and the separation duct **86**. In the following, the outer frame assembly **72**, the bottom plate **73**, and the paper stacking tray **74** will be described first in reference to FIGS. **2** and **3**, and the paper drawing section **75** will be described later in detail.

FIG. **3** is a perspective view of an outer frame assembly, a bottom plate, and a paper stacking tray, with a paper drawing section being removed.

The paper stacking tray **74** has open groove sections **74***a* extending in the transport direction H of the printing paper. There is provided a printing paper rear end guide **76** in the open groove sections **74***a* so that the printing paper rear end guide **76** stands out of the open groove sections **74***a*. The end of the printing paper stacked on the paper stacking tray **74** as pointed at by the arrow representing the transport direction H may be referred to as the "front end." The opposite end may be referred to as the "rear end." The direction indicated by the transport direction H may be referred to as "forward." The opposite direction may be referred to as "backward." The direction of the front end of the printing paper stacked on the paper stacking tray **74** is taken as the longitudinal direction N.

The printing paper rear end guide **76** includes a guiding pillar section **76***a* that faces the rear end of the printing paper stacked on the paper stacking tray **74** and a guiding head section **76***b* supported by the guiding pillar section **76***a*. The printing paper rear end guide **76** is supported so that the guide **76** can move reciprocally along the transport direction H of the printing paper in the open groove sections **74***a* on the bottom plate **73** and be fixed at any given position. Moving the printing paper rear end guide **76** forward causes the guiding pillar section **76***a* to come into contact with the rear end of the printing paper; elevating the paper stacking tray **74** causes the top face of the printing paper to come into contact with the guiding head section **76***b*.

There is provided a stack tray dent section **74***b* on either side of the paper stacking tray **74** with respect to its longitudinal direction N and an auxiliary duct **77** in each stack tray dent section **74***b*. The two auxiliary ducts **77** are supported by the outer frame assembly **72** so that the ducts **77** can move reciprocally along the longitudinal direction N in the stack tray dent section **74***b*, move in conjunction closer to, or away from, each other, and fixed at any given position.

The outer frame assembly **72** is provided in such a manner as to surround the printing paper stacked on the paper stacking tray **74** in a planar view and includes frame assembly openings **72***a*, two on either side of the assembly **72** with respect to its longitudinal direction N, and a contact plate **72***b* into which the front end of the printing paper comes into contact. From each assembly opening **72***a*, a protrusion **74***c* formed on the paper stacking tray **74** extends outside the outer

frame assembly **72**. The contact plate **72***b* has a notch section **72***c* where the contact plate **72***b* faces a first separation opening **86***b* (see FIGS. **5** and **7** which will be detailed later) of the separation duct **86**.

Each auxiliary duct **77** is a hollow body with auxiliary openings **77***a* on a face thereof that faces a side of the printing paper stacked on the paper stacking tray **74** and has an internal air passage. There is provided an auxiliary fan **79** outside each auxiliary duct **77**. The air sucked in by the auxiliary fan **79** is fed to the air passage in the auxiliary duct **77** and blown into the outer frame assembly **72** through the auxiliary openings **77***a*.

A wind-up pulley **90** is provided on each side of the outer frame assembly **72** with respect to the longitudinal direction N outside the outer frame assembly **72**. Each wind-up pulley **90** is connected to two wires **93** that are in turn each connected to one of the protrusions **74***c* that is disposed on the same side as that wind-up pulley **90**. The wires **93** are routed over driven pulleys **94** and connected to the wind-up pulley **90**. In other words, a wire **93** is connected to each of the four protrusions **74***c*. The two wind-up pulleys **90** are fixed at the ends of a common rod **91** that is supported in a freely rotatable manner. A pulse motor **92** connected to the rod **91** drives/rotates the rod **91** for positive and negative rotation of the wind-up pulleys **90**. The rotation in turn causes the wires **93** to be wound on, and unwound from, the wind-up pulleys **90**. The winding and unwinding of the wires **93** moves up/down the paper stacking tray **74** along the stacking direction S. The height of the paper stacking tray **74** is adjustable by controlling the direction and angle of rotation of the pulse motor **92**.

Next, the structure of the paper drawing section will be described in detail in reference to FIGS. **4** to **7**.

FIG. **4** is a perspective view of the paper drawing section as viewed obliquely downward from the front. FIG. **5** is a perspective view of the paper drawing section as viewed obliquely upward from the rear. FIG. **6** is a perspective view of the paper drawing section as viewed obliquely downward from the rear. FIG. **7** is an enlarged cross-sectional view primarily showing the paper drawing section as taken according to arrows B-B shown in FIG. **2**.

The air sucking duct **85** is a hollow body. As illustrated in FIG. **4**, the air sucking duct **85** has an air channel extending in the longitudinal direction N and is coupled to the air sucking fan **84** via an sucking-coupling section **85***a* disposed at an end with respect to the longitudinal direction N. The air sucking duct **85** is disposed extending in the longitudinal direction N over the top face of the printing paper stacked on the paper stacking tray **74**. The air sucking duct **85** has paper sucking ports **85***e* (see FIG. **7** for detail) on a face thereof that is over the top face of the printing paper (the bottom face **85***g* of the air sucking duct **85**). The paper sucking ports **85***e* extend to the internal channel. The air sucking duct **85** has a roller coupling section **85***h* at a front end section **85***c* and another roller coupling section **85***h* at a rear end section **85***d* (see FIG. **4**) with respect to the transport direction H. The roller coupling sections **85***h* stick out externally. A roller rotational shaft **82***a* supporting a roller **82** and a roller rotational shaft **83***a* supporting a roller **83** are connected to the roller coupling section **85***h*.

The roller **82** is supported by the roller rotational shaft **82***a*, the roller **83** is supported by the roller rotational shaft **83***a*, and the roller rotational shaft **82***a* and the roller rotational shaft **83***a* are connected to driving means (not shown).

The paper transport belts **81** are stretched around the rollers **82** and **83** and disposed, although not precisely shown, so that the belts **81** are slightly distanced from the top face **85***b* of the air sucking duct **85** and in contact with the bottom face **85***g* of the air sucking duct **85**. As the driving means rotates one of the rollers (the roller **82**), the other roller **83** is driven to rotate so that the paper transport belts **81** can rotate. In the present embodiment, the paper transport member is an equivalent of the paper transport belts **81**. The paper transport belts **81** have numerous air passage holes **81***a* so that air is sucked through the air passage holes **81***a* and the air sucking duct **85** to the air sucking fan **84**.

As indicated by arrows F in FIGS. **4** to **6**, the air sucking fan **84** sucks air through the paper sucking ports **85***e* and the sucking-coupling section **85***a* to the air inlet **84***a* of the air sucking fan **84**. Then, as indicated by arrows F in FIG. **7**, that air sucks the top face of the printing paper stacked on the paper stacking tray **74** via the air passage holes **81***a*. The printing paper is drawn on its top face onto the paper transport belts **81** and transported in the transport direction H by the rotation of the paper transport belts **81**.

The structure of the air sucking fan **84** and the separation fan **88** will be described later in detail in reference to FIGS. **8**A and **8**B.

The separation duct **86** is a hollow body. As illustrated in FIG. **4**, The separation duct **86** has an air channel extending in the longitudinal direction N and is coupled to the separation fan **88** via a separation coupling section **86***a* (see also FIG. **2**) disposed at an end with respect to the longitudinal direction N. As illustrated in FIG. **7**, the separation duct **86** is disposed facing the front end of the printing paper stacked on the paper stacking tray **74**. The separation duct **86** has the first separation opening **86***b* in a face thereof that faces the front end of the printing paper (internal face **86***d* of the separation duct **86**). The first separation opening **86***b* extends to the internal channel. The internal face **86***d* is disposed overlapping the external face of the contact plate **72***b* of the outer frame assembly **72**. The first separation opening **86***b* faces the interior of the outer frame assembly **72** via the notch section **72***c*. The separation duct **86** has a second separation opening **86***e* that faces the paper transport belts **81**.

As indicated by arrows K in FIGS. **4** and **5**, the separation fan **88** feeds air from the air outlet **88***b* through the separation coupling section **86***a* to the first separation opening **86***b* and the second separation opening **86***e*. That air is blown through the first separation opening **86***b* and the second separation opening **86***e* to the interior of the outer frame assembly **72**. As indicated by arrows K in FIG. **7**, the air blown out through the first separation opening **86***b* is fed at the front end of the printing paper stacked on the paper stacking tray **74** so that a few top sheets of the stacked printing paper can become loosened up. In this circumstance, the air fed through the auxiliary ducts **77** (see FIG. **3**) levitates the sheets of printing paper stacked on the paper stacking tray **74** toward the paper transport belts **81** for easy sucking of printing paper. The air blown out through the second separation opening **86***e* is fed between the sheets of printing paper levitated from the paper stacking tray **74** so that the air can separate the individual sheets of printing paper. The top one of the separated sheets is drawn onto the paper transport belts **81**, whereas the other sheets are stacked back on the paper stacking tray **74**.

The relay duct **87** is a hollow body. As illustrated in FIG. **4**, the relay duct **87** has a channel extending in the transport direction H and is coupled at one of its ends to the air outlet **84***b* of the air sucking fan **84** and coupled at the other end to the air inlet **88***a* of the separation fan **88**. The air blown out by the air sucking fan **84** is fed to the separation fan **88** via the relay duct **87**. The channel in the relay duct **87** will be described later in detail in reference to FIG. **8**A.

The relay duct **87** and the separation duct **86** are coupled at a predetermined angle. The separation fan **88** is disposed

where the relay duct **87** and the separation duct **86** are coupled. This structure changes the direction of the air that flows through the separation fan **88** and provides the separation duct **86** along the air flow coming from the separation fan **88**. That in turn reduces the loss that would otherwise be caused by wall faces and other obstacles, thereby achieving efficient printing paper separation.

Specifically, the predetermined angle is from 80° to 100° and preferably equal to 90°. In other words, the relay duct **87** and the separation duct **86** are coupled at a 90° angle. This 90° coupling enables air to be fed normal to the air inlet **88***a* of the separation fan **88**. The separation fan **88** hence collects air efficiently.

The air coming out of the separation duct **86** is partially sucked into the air sucking duct **85**. This arrangement establishes an air channel between the separation duct **86** and the air sucking duct **85**. Therefore, circulating air that flows in the paper feeding device **71** reduces loss of air for efficient operation.

An end (sucking front end section **85***f*) of the air sucking duct **85** that is opposite the sucking-coupling section **85***a* is connected to an end (separating front end section **86***c*) of the separation duct **86** that is opposite the separation coupling section **86***a*. Although FIGS. **4** to **6** show the relay duct **87** being separately formed from the air sucking duct **85** and the separation duct **86**, the present invention is by no means limited to this concrete example. Alternatively, the air sucking duct **85**, the separation duct **86**, and the relay duct **87** may be formed as a single body. In other words, the relay duct **87**, the sucking-coupling section **85***a*, and the separation coupling section **86***a* may be formed as a single body by, for example, providing the relay duct **87** with thick external walls, so long as channels that correspond to the air sucking duct **85**, the separation duct **86**, and the relay duct **87** are independently formed.

Next, the air sucking fan and the separation fan will be described in reference to FIGS. **8**A, **8**B, and **12**.

FIG. **8**A is a front view of only the air sucking fan and the separation fan. FIG. **8**B is a side view of the air sucking fan and the separation fan as viewed from the direction indicated by arrow A in FIG. **8**A. FIG. **12** is a cross-sectional view taken according to arrows C-C in FIG. **9**.

The air sucking fan **84** is, for example, a sirocco fan or like centrifugal fan. The air sucking fan **84** sucks in air through the air inlet **84***a* and pressurizes it before blowing out through the air outlet **84***b*. The air sucking fan **84** includes blades **84***c*, a fan casing **84***d*, and a duct section **84***e*. In the present embodiment, the separation fan **88** has a similar structure to the air sucking fan **84**, and its description is omitted here.

The blades **84***c* are rotated by driving means (not shown) to send air radially outside the air sucking fan **84** by means of the centrifugal force generated by its rotation. A bearing section **84***f* is disposed at the center of the air inlet **84***a*. The blades **84***c* are disposed radially around the bearing section **84***f*. The blades **84***c* are disposed, for example, standing on a circular plate **84***j* connected to a rotation axis **84***h*. The bearing section **84***f* includes therein the rotation axis **84***h* connected to driving means. The circular plate **84***j* rotates around the rotation axis **84***h* to achieve rotational motion of the blades **84***c*.

The fan casing **84***d* has a columnar space that contains the blades **84***c* therein. The fan casing **84***d* is substantially cylindrical and provided with the air inlet **84***a* on a substantially circular, primary face **84***g*. The primary face **84***g* of the fan casing **84***d* is, for example, 120 mm wide (housing vertical width FW**1**). A side face of the fan casing **84***d* has an opening through which the air sucking fan **84** is coupled to the duct section **84***e*. The side face of the fan casing **84***d* is, for example, 33 mm wide (side face width FW**3**). The air inlet **84***a* is circular in a front view and has a diameter (opening diameter FWh) of, for example, 80 mm.

The bearing section **84***f* is formed like a cup sticking out at the primary face **84***g* and has a diameter (rotation axis width FWp) of, for example, 58 mm. In the following, the width from the bearing section **84***f* to the air inlet **84***a* in a front view may be referred to as an effective opening width FWy for the sake of description. Air can be moved into the air sucking fan **84** by supplying air between the bearing section **84***f* and the air inlet **84***a* (effective opening width FWy). In contrast, the air that hits the bearing section **84***f* returns without entering the interior of the air sucking fan **84**. In the following, the region where the air sucking fan **84** is able to suck in air will be referred to as the air sucking region, and the air sucking region corresponds to the effective opening width FWy. There is provided a gap between the blades **84***c* and the bearing section **84***f* in the present embodiment. The distance between the blades **84***c* and the bearing section **84***f* may be adjusted in a suitable manner so long as the blades **84***c* are partially located in the effective opening width FWy in a front view.

The duct section **84***e* is a hollow tube having a rectangular cross-section normal to the air flow direction and is formed integral to the fan casing **84***d*. The duct section **84***e* is coupled at one of its ends to a side face of the fan casing **84***d* and at the other end, constitutes the air outlet **84***b* to externally eject the air that flows through the internal channel of the duct section **84***e*. The width (housing horizontal width FW**2**) from the air outlet **84***b* to the other end of the fan casing **84***d* in a front view is, for example, 120 mm. As mentioned earlier, in a side view, the air outlet **84***b* is rectangular. The air outlet **84***b* has an opening width (ejection horizontal width VW**1**) of, for example, 26 mm in the direction of the rotation axis and an opening width (ejection vertical width VW**2**) of, for example, 51 mm in the direction normal to the rotation axis. In other words, the air outlet **84***b* has a greater ejection vertical width VW**2** than the ejection horizontal width VW**1**.

The air sucking fan **84** and the separation fan **88** have the same structure. The air inlet **88***a*, air outlet **88***b*, blades **88***c*, fan casing **88***d*, duct section **88***e*, bearing section **88***f*, primary face **88***g*, rotation axis **88***h*, and circular plate **88***j* of the separation fan **88** are equivalents of the air inlet **84***a*, air outlet **84***b*, blades **84***c*, fan casing **84***d*, duct section **84***e*, bearing section **84***f*, primary face **84***g*, rotation axis **84***h*, and circular plate **84***j* of the air sucking fan **84** respectively.

As mentioned earlier, the air sucking fan **84** and the separation fan **88**, being identical, facilitates reduction of unwanted noise generated by the fans. If the fans have approximately equal rotational speeds and cycles, the frequencies of their unwanted noise are confined to a narrow range of frequencies. The noise can be thus reduced without addressing a wide range of frequencies.

As mentioned earlier, the widths of the air sucking fan **84** and the separation fan **88** are determined by the widths (housing vertical width FW**1**, housing horizontal width FW**2**, and side face width FW**3**) of the fan casing **84***d* and the duct section **84***e*. In the present embodiment, the side face width FW**3** is the smallest width, and the air sucking fan **84** and the separation fan **88** have the smallest widths in the direction of the rotation axis.

The separation fan **88** is preferably set up to generate a higher wind pressure than does the air sucking fan **84**. According to the setup, the separation fan **88** generates an increased wind pressure, which compensates for the loss that occurs during its passage in the relay duct **87**. A longer channel inevitably lowers the wind pressure, albeit slightly. An output difference between the fans ensures a consistent wind

pressure. Specifically, the wind pressure of the air sucking fan **84** is 200 Pa, and the wind pressure of the separation fan **88** is 380 Pa.

The broken lines in FIG. **8**A, in a front view, indicate the channel (duct region DR) in the relay duct **87** as projected onto the primary face **88***g* of the separation fan **88**. The duct region DR is rectangular and has a width of 26 mm in the longitudinal direction N (horizontal direction in the figure) and a width of 51 mm in the stacking direction S (vertical direction in the figure). In other words, the duct region DR has the same shape as the air outlet **84***b* of the air sucking fan **84**. The duct region DR is preferably as large as, or larger than, the air outlet **84***b* of the air sucking fan **84**.

The duct region DR is preferably positioned to face the blades **88***c* and to maximize the area in which the duct region DR overlaps a part of the effective opening width FWy. In other words, when the area in which the duct region DR overlaps a part of the effective opening width FWy is a maximum, the air outlet **84***b* of the air sucking fan **84** is disposed at such a position that the area in which the air outlet **84***b* overlaps the air sucking region is maximized. According to the structure, the separation fan **88** sucks in as much of the air coming out of the air sucking fan **84** as possible. That in turn increases the air coming out of the separation fan **88**. In other words, the air fed directly into the separation fan is increased by increasing the area of the opening that faces the air sucking region. The area in which the air outlet **84***b* of the air sucking fan **84** overlaps the air sucking region is the area in which the air outlet **84***b* overlaps the effective opening width FWy in a front view of the primary face **88***g* of the separation fan **88**.

As mentioned earlier, the relay duct **87** has an opening that faces the blades **88***c* of the separation fan **88**. According to the structure, the air coming out of the relay duct **87** directly hits the blades **88***c* of the separation fan **88**, which enables efficient feeding of air to the separation fan **88**.

The air sucking region is shaped like a circular ring, and the air outlet **84***b* of the air sucking fan **84** is rectangular, when viewed normal to a plane (primary face **88***g*) in which the air inlet **88***a* of the separation fan **88** lies. Preferably, one of sides of a projection of the air outlet **84***b* of the air sucking fan **84** onto the separation fan **88** matches a tangent to an external circle of the air sucking region. The structure specifies the position of the air outlet **84***b* of the air sucking fan **84**. That in turn facilitates designing of a structure that maximizes the area in which the air outlet **84***b* of the air sucking fan **84** overlaps the air sucking region.

In the present embodiment, the longer sides of the air outlet **84***b* of the air sucking fan **84** are disposed at a position (right end of the air inlet **88***a* of the separation fan **88**) where the distance from the air outlet **88***b* of the separation fan **88** as measured in the longitudinal direction N (horizontal direction in FIG. **8**A) is a maximum. Alternatively, for example, the longer sides may be disposed at a position (left end of the air inlet **88***a* of the separation fan **88**) where the distance from the air outlet **88***b* of the separation fan **88** as measured in the longitudinal direction N is a minimum. In addition, although the longer sides of the air outlet **84***b* of the air sucking fan **84** are disposed normal to the longitudinal direction N, the longer sides may be tilted with respect to the longitudinal direction N so long as the longer sides match the tangent to the air outlet **88***b* of the separation fan **88**.

If the air inlet **88***a* of the separation fan **88** and the opening of the relay duct **87** have different shapes, the air coming out of the relay duct **87** may be prevented from leaking to the outside by, for example, expanding only the part of the opening in which the separation fan **88** is coupled to the relay duct **87** in width according to the air inlet **88***a*. The same arrangement could apply to the coupling of the air sucking fan **84** and the air sucking duct **85** (sucking-coupling section **85***a*). In addition, the relay duct **87** may cover the primary face **88***g* so that the air coming out of the opening of the relay duct **87** could be vented only to the region that is part of the air inlet **88***a* facing the air outlet **84***b*.

Next will be described the size of the paper drawing section in reference to drawings.

FIG. **9** is a plan view of the removed paper drawing section. FIG. **10** is a side view of the paper feeding device shown in FIG. **2**.

The air sucking duct **85** (except for the sucking-coupling section **85***a*) has a width KDn of 455 mm in the longitudinal direction N, a width KDh of 50 mm in the transport direction H, and a width KDs (see FIG. **5**) of 25 mm in the stacking direction S. The air sucking duct **85** is thus longer in the longitudinal direction N, and the longitudinal direction N of the air sucking duct **85** matches the longitudinal direction N.

The separation duct **86** (except for the separation coupling section **86***a* and the separating front end section **86***c*) has a width BDn of 395 mm in the longitudinal direction N, a width BDh of 33 mm in the transport direction H, and a width BDs of 65 mm in the stacking direction S. The separation duct **86** is thus longer in the longitudinal direction N, and the longitudinal direction N of the separation duct **86** matches the longitudinal direction N. The width BDh of the separation duct **86** in the transport direction H is a minimum width, and the transport direction H is a minimum width direction of the separation duct **86**.

The air sucking fan **84** has the air inlet **84***a* in a plane normal to the longitudinal direction N and the air outlet **84***b* in a plane normal to the transport direction H. The rotation axis of the air sucking fan **84** thus extends in the longitudinal direction N. Therefore, the minimum width direction of the air sucking fan **84** matches the longitudinal direction N.

The separation fan **88** has the air inlet **88***a* in a plane normal to the transport direction H and the air outlet **88***b* in a plane normal to the longitudinal direction N. The rotation axis of the separation fan **88** thus extends in the transport direction H. Therefore, the minimum width direction of the separation fan **88** matches the transport direction H.

As mentioned earlier, the air sucking fan **84** is disposed so that the longitudinal direction N of the air sucking duct **85** matches the minimum width direction of the air sucking fan **84**, with the longitudinal direction N being along the front end of the printing paper stacked on the paper stacking tray **74**. The separation duct **86** is disposed so that the longitudinal direction N of the air sucking duct **85** is along the longitudinal direction N of the separation duct and that the transport direction H matches the minimum width direction of the separation duct **86**. The separation fan **88** is disposed so that the minimum width direction of the separation duct **86** is along the minimum width direction of the separation fan **88**.

According to the structure, the minimum width direction of the air sucking fan **84** matches the longitudinal direction of the air sucking duct **85**. That reduces the width of the paper drawing section **75** constituted by ducts and fans in a longitudinal direction N. The matching of the minimum width directions of the separation duct **86** and the separation fan **88** with the transport direction H reduces the width of the paper drawing section **75** in the transport direction H. Reducing the widths in the longitudinal direction N and in the transport direction H to possible minimums allows for reduction of the paper feeding device **71** in size.

The separation fan **88** has the air outlet **88***b* in a plane normal to the longitudinal direction N, and the air outlet **88***b* of the separation fan **88** is wider in the stacking direction S

(ejection vertical width VW2) than in the transport direction H (ejection horizontal width VW1). According to the structure, the air outlet **88***b* of the separation fan **88** is wider in the stacking direction S, which ensures a sufficient cross-sectional area for the channel Since the separation fan **88** and the separation duct **86** have their minimum width directions matched with the transport direction H, the separation fan **88** and the separation duct **86** are not allowed to have an increased width in the transport direction H. Their widths can however be readily increased in the stacking direction S in which a predetermined area is ensured for the provision of the paper stacking tray **74**.

The air sucking fan **84** has the air outlet **84***b* in a plane normal to the transport direction H, and the air outlet **84***b* of the air sucking fan **84** is wider in the stacking direction S (ejection vertical width VW2) than in the longitudinal direction N (ejection horizontal width VW1). According to the structure, the air outlet **84***b* of the air sucking fan **84** is wider in the stacking direction S, which ensures a sufficient cross-sectional area for the channel. Since the air sucking fan **84** has its minimum width direction matched with the longitudinal direction N of the air sucking duct **85**, the air sucking fan **84** is not allowed to have an increased width in the longitudinal direction N. Its width can however be readily increased in the stacking direction S in which a predetermined area is ensured for the provision of the paper stacking tray **74**.

As illustrated in FIG. **9**, the air sucking duct **85**, the relay duct **87**, and the separation duct **86** have a horseshoe-like shape in a planar view. Therefore, the air sucking duct **85** and the separation duct **86** extend in the same direction from the relay duct **87**. That enables the footprint of the paper feeding device **71** to be reduced, allowing for reduction in size. That also facilitates designing of a structure in which the air sucking duct **85** and the separation duct **86** are closely located, readily allowing air to circulate from the separation duct **86** to the air sucking duct **85**.

Next will be described the paper feed operation by a paper feeding device in reference to FIGS. **2** and **11**.

FIG. **11** is a simplified cross-sectional view of a paper feeding device in accordance with an embodiment of the present invention.

First, sheets of printing paper are stacked on the paper stacking tray **74** and properly positioned. To stack printing paper on the paper stacking tray **74**, the printing paper rear end guide **76** is pushed backward to move the printing paper rear end guide **76** and the contact plate **72***b* away from each other. Then, the auxiliary ducts **77** are moved away from each other in such directions that the auxiliary ducts **77** can be mutually separated. In this situation, printing paper is stacked on the paper stacking tray **74**, and the printing paper rear end guide **76** is pushed forward so that the guiding pillar section **76***a* can push the rear end of the printing paper in the transport direction H. The printing paper, pushed by the guiding pillar section **76***a*, slips on the paper stacking tray **74** until its front end comes in contact with the contact plate **72***b*. The front and rear ends of the printing paper are thus sandwiched between the contact plate **72***b* and the guiding pillar section **76***a* for positioning of the printing paper. The auxiliary ducts **77** are moved in such directions that the auxiliary ducts **77** can mutually come closer. Both ends of the printing paper with respect to the longitudinal direction N are thus sandwiched between two auxiliary ducts **77** for positioning of the printing paper.

Next, the wind-up pulleys **90** (see FIG. **3**) are rotated to elevate the paper stacking tray **74** for positioning of the printing paper at a predetermined height. The paper stacking tray **74** is elevated, for example, until the top sheet of printing paper comes into contact with the guiding head section **76***b*.

Air is then fed to the auxiliary ducts **77** to blow air from the auxiliary ducts **77** above the side faces of the printing paper stacked on the paper stacking tray **74** to levitate sheets of printing paper. Air is also fed from the air sucking fan **84** and the separation fan **88** to the separation duct **86** to blow air from the first separation opening **86***b* at the front end of the printing paper, to loosen up the sheets of printing paper. In this situation, the air blown out of the second separation opening **86***e* separates the levitated sheets of printing paper.

Air is then sucked by the air sucking fan **84** and the separation fan **88** through the air sucking duct **85**, the air passage holes **81***a*, and the paper sucking ports **85***e* to draw (suck) a sheet of printing paper onto the paper transport belts **81**. In response to this, the rollers **82** and **83** are rotated to rotate the paper transport belts **81**. The sheet is thus drawn out of the stack and transported in the transport direction H to the transport rollers **31** in the image forming device **1**. Another sheet of printing paper is then drawn (sucked) onto the paper transport belts **81** and transported. Following that, more printing paper is transported in the same manner, a sheet at a time, from the paper feeding device **71** to the image forming device **1**.

As mentioned earlier, the image forming device **1** includes the paper feeding device **71**. According to the structure, the image forming device **1**, including the paper feeding device **71** in accordance with the present invention, achieves the same functions and effects as the paper feeding device **71** in accordance with the present invention.

The aforementioned examples are for illustrative purposes only in every respect and should not be subjected to any restrictive interpretations. The scope of the present invention is defined only by the claims and never bound by the specification. Those modifications and variations that may lead to equivalents of claimed elements are all included within the scope of the invention.

REFERENCE SIGNS LIST

1 Image Forming Device
71 Paper Feeding Device
74 Paper Stacking Tray
81 Paper Transport Belt (Exemplary Paper Transport Member)
84 Air Sucking Fan
84*a* Air Inlet (Part of Air Sucking Fan)
84*b* Air Outlet (Part of Air Sucking Fan)
85 Air Sucking Duct
86 Separation Duct
87 Relay Duct
88 Separation Fan
88*a* Air Inlet (Part of Separation Fan)
88*b* Air Outlet (Part of Separation Fan)
H Transport Direction
N Longitudinal direction
S Stacking Direction

The invention claimed is:

1. A paper feeding device, comprising:

a paper stacking tray that carries thereon stacked sheets of printing paper and moves up/down along a stacking direction of the sheets of printing paper, wherein a longitudinal direction is along a front end of the printing paper stacked on the paper stacking tray;

a paper transport member that sucks in air to suck and transport a sheet of printing paper stacked on the paper stacking tray;

a separation duct that, disposed facing the front end of the printing paper stacked on the paper stacking tray, constitutes a channel for air separating the printing paper;

a separation fan that, coupled to an end of the separation duct with respect to the longitudinal direction, generates an air flow separating the printing paper stacked on the paper stacking tray;

an air sucking duct that, disposed in the longitudinal direction facing a top face of the printing paper stacked on the paper stacking tray, constitutes a channel for air sucking a sheet of printing paper stacked on the paper stacking tray;

an air sucking fan that, coupled to an end of the air sucking duct with respect to the longitudinal direction, generates an air flow separating the printing paper stacked on the paper stacking tray; and

a relay duct that guides air coming out of the air sucking fan to the separation fan,

wherein

the air sucking fan and the separation fan are arranged so that the air sucking fan and the separation fan have rotation axes thereof substantially parallel to a top face of the printing paper stacked on the paper stacking tray and also so that the air sucking fan ejects air from an air outlet thereof in the same direction as the separation fan sucks in air through an air inlet thereof; and

the relay duct extends along a straight line from the air outlet of the air sucking fan to the air inlet of the separation fan.

2. The paper feeding device as set forth in claim **1**, wherein the relay duct and the separation duct are coupled at a predetermined angle, and the separation fan is disposed where the relay duct and the separation duct are coupled.

3. The paper feeding device as set forth in claim **2**, wherein the predetermined angle is equal to 90°.

4. The paper feeding device as set forth in claim **2**,

wherein the air sucking duct sucks in air coming out of the separation duct.

5. The paper feeding device as set forth in claim **1**, wherein the relay duct has an opening that faces blades of the separation fan.

6. The paper feeding device as set forth in claim **1**, wherein the air outlet of the air sucking fan is disposed at such a position that the air outlet of the air sucking fan overlaps a part of an air sucking region from which the separation fan sucks in air and that an area in which the air outlet of the air sucking fan overlaps the air sucking region is maximized.

7. The paper feeding device as set forth in claim **6**, wherein

the air sucking region is shaped like a circular ring, and the air outlet of the air sucking fan is rectangular, when viewed normal to a plane in which the air inlet of the separation fan lies, and

one of sides of a projection of the air outlet of the air sucking fan onto the separation fan matches a tangent to an external circle of the air sucking region.

8. A paper feeding device, comprising:

a paper stacking tray that carries thereon stacked sheets of printing paper and moves up/down along a stacking direction of the sheets of printing paper;

a paper transport member that sucks in air to suck and transport a sheet of printing paper stacked on the paper stacking tray;

letting a longitudinal direction be along a front end of the printing paper stacked on the paper stacking tray,

a separation duct that, disposed facing the front end of the printing paper stacked on the paper stacking tray, constitutes a channel for air separating the printing paper;

a separation fan that, coupled to an end of the separation duct with respect to the longitudinal direction, generates an air flow separating the printing paper stacked on the paper stacking tray;

an air sucking duct that, disposed in the longitudinal direction facing a top face of the printing paper stacked on the paper stacking tray, constitutes a channel for air sucking the sheet of printing paper stacked on the paper stacking tray; and

an air sucking fan that, coupled to an end of the air sucking duct with respect to the longitudinal direction, generates an air flow sucking the sheet of printing paper stacked on the paper stacking tray,

wherein

the air sucking fan is disposed so that a longitudinal direction of the air sucking duct matches a minimum width direction of the air sucking fan,

the separation duct is disposed along the longitudinal direction and such that a transport direction of the printing paper matches a minimum width direction of the separation duct, and

the separation fan is disposed so that the minimum width direction of the separation duct is along a minimum width direction of the separation fan.

9. The paper feeding device as set forth in claim **8**, wherein the separation fan has an air outlet in a plane normal to the longitudinal direction, the air outlet of the separation fan being wider in the stacking direction than in the transport direction.

10. The paper feeding device as set forth in claim **8**, wherein the air sucking fan has an air outlet in a plane normal to the transport direction, the air outlet of the air sucking fan being wider in the stacking direction than in the longitudinal direction.

11. The paper feeding device as set forth in claim **8**, further comprising a relay duct that guides air coming out of the air sucking fan to the separation fan, wherein

the relay duct and the separation duct are coupled at a predetermined angle, and

the separation fan is disposed where the relay duct and the separation duct are coupled.

12. The paper feeding device as set forth in claim **11**, wherein the predetermined angle is equal to 90°.

13. The paper feeding device as set forth in claim **11**, wherein the relay duct has an opening that faces blades of the separation fan.

14. The paper feeding device as set forth in claim **1**, wherein the air sucking fan and the separation fan have a common structure.

15. The paper feeding device as set forth in claim **1**, wherein the separation fan generates a higher wind pressure than does the air sucking fan.

16. An image forming device, comprising the paper feeding device as set forth in claim **1**.

17. The paper feeding device as set forth in claim **8**, wherein the air sucking fan and the separation fan have a common structure.

18. The paper feeding device as set forth in claim **8**, wherein the separation fan generates a higher wind pressure than does the air sucking fan.

19. An image forming device, comprising the paper feeding device as set forth in claim **8**.

20. The paper feeding device as set forth in claim **1**, wherein the air outlet of the air sucking fan and the air inlet of the separation fan face each other.

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